

IN THE CLAIMS

This listing of the claim will replace all prior versions and listings of claim in the present application.

Listing of Claims

1. (currently amended) A disk array device, ~~which can be connected to a~~ for storing data in response to communications from a host device so that they are capable of communicating with each other, the disk array device comprising:
 - a disk array control unit which performs control of the entire disk array device;
 - a host side data transfer control unit which controls data transfer to and from the host device;
 - a disk array including at least ~~plural~~ a plurality of data disk drives which constitute one parity group and one or more spare disk drives, wherein the one parity group has a large number of data stripes which are formed over storage areas of the plural data disk drives and the large number of data stripes can be partitioned into two or more sets of the data stripes;
 - a cache memory which is used for temporary storage of data to be transferred between the host device and the disk array; and
 - a subordinate side transfer control unit which controls data transfer to and from the disk array,wherein the disk array control unit comprises:
 - a prediction section which predicts the likelihood of occurrence of a failure for each data disk drive;

a disk drive resource information table which includes for each data disk drive information indicating a status of said data disk drive and information of a rate of occurrence of errors in said data disk drive,

a spare disk drive resource information table which includes for each spare disk drive information indicating a status of said spare disk drive and information regarding storage areas of said spare disk drive used for recovery with respect to a corresponding data disk drive,

wherein said prediction section predicts the likelihood of occurrence of a failure based on information contained in said disk drive resource information table, and

a divided data copy section which, in response to a prediction that occurrence of a failure is likely to occur with respect to a data disk drive, and based on information contain in said spare disk drive resource information table, selects two or more data disk drives out of the plural data disk drives as objects of divided data copy according to the predicted likelihood of the occurrence of a failure, selects two or more divided storage areas by selecting one divided storage area from each of the selected two or more data disk drives, the selected two or more divided storage areas belonging to different sets of the data stripes in the parity group, and controls the subordinate side transfer control unit and the cache memory so as to copy data in the selected two or more divided storage areas to the one or more spare disk drives.

2. (original) A disk array device according to claim 1,

wherein the disk array control unit further comprises a dynamic sparing section which selects one data disk drive as an object of dynamic sparing out

of the plural data disk drives according to the predicted likelihood of occurrence of a failure, selects remaining divided storage areas, from which data has not been copied by the divided data copy section, from the selected one data disk drive, and controls the subordinate side transfer control units and the cache memory so as to copy data in the selected remaining divided storage areas to the spare disk drives.

3. (original) A disk array device according to claim 2,

wherein, in the case in which the predicted likelihood of occurrence of a failure of a first data disk drive in the plural data disk drives has reached a first level, the divided data copy section selects at least the first data disk drive and a separate second data disk drive as objects of the divided data copy, and

in the case in which the predicted likelihood of occurrence of a failure of the first data disk drive has reached a second level which is higher than the first level, the dynamic sparing section selects the first data disk drive as an object of the dynamic sparing.

4. (original) A disk array device according to claim 1,

wherein, in the case in which the predicted likelihood of occurrence of a failure of the first disk drive among the plural disk drives has reached a predetermined level, the divided data copy section selects the first data disk drive and a second data disk drive, which has the largest predicted likelihood of occurrence of a failure after the first data disk drive, as objects of the divided data copy.

5. (original) A disk array device according to claim 1,
wherein the divided data copy section controls the subordinate side transfer control unit and the cache memory so as to read out data simultaneously from the selected two or more divided storage areas in a course of copying the data in the selected two or more divided storage areas.

6. (original) A disk array device according to claim 1,
wherein the disk array control unit further comprises a spare data updating section which, in the case in which a new request for writing data in the selected two or more divided storage areas from the host device is received from the host side data transfer unit after the data in the selected two or more divided storage areas is started to be copied to the one or more spare disk drives, controls the subordinate side transfer control unit and the cache memory so as to write the new data received from the host device in the selected two or more divided storage areas and write the data in the spare disk drives as well.

7. (original) A disk array device according to claim 1,
wherein the divided data copy section selects first and second data disk drives as objects of the divided data copy from the plural data disk drives, selects a first divided storage area belonging to a set of front side data stripes in the parity groups from the first data disk drive, selects a second divided storage area belonging to a set of rear side data stripes following the set of front side data stripes from the second data disk drive, and controls the

subordinate side transfer control unit and the cache memory so as to copy data in the first and the second divided storage areas to the spare disk drives.

8. (original) A disk array device according to claim 1,
wherein the two or more divided storage areas selected from the two or more data disk drives by the divided data copy section have substantially the same size.

9. (original) A disk array device according to claim 1,
wherein the two or more divided storage areas selected from the two or more data disk drives by the divided data copy section have different sizes according to the predicted likelihood of occurrence of a failure of the two or more data disk drives.

10. (original) A disk array device according to claim 1,
wherein the prediction section stores an error occurrence history for each of the data disk drives and predicts the likelihood of occurrence of a failure for each of the data disk drives on the basis of the stored error occurrence history.

11. (currently amended) A method for use in a disk array device,
which can be connected to a host device so that they are capable of communicating with each other, comprising:
a disk array control unit which performs control of the entire disk array device;

a host side data transfer control unit which controls data transfer to and from the host device;

a disk array including at least plural data disk drives which constitute one parity group and one or more spare disk drives, wherein the one parity group has a large number of data stripes which are formed over storage areas of the plural data disk drives and the large number of data stripes can be partitioned into two or more sets of the data stripes;

a cache memory which is used for temporary storage of data to be transferred between the host device and the disk array; and

a subordinate side transfer control unit which controls data transfer to and from the disk array,

wherein said disk array control unit includes a disk drive resource information table which includes for each data disk drive information indicating a status of said data disk drive and information of a rate of occurrence of errors in said data disk drive and a spare disk drive resource information table which includes for each spare disk drive information indicating a status of said spare disk drive and information regarding storage areas of said spare disk drive used for recovery with respect to a corresponding data disk drive,

wherein the disk array control unit operating to spare data in the data disk drive using the spare disk drive, the method comprising:

a step of predicting the likelihood of occurrence of a failure for each of the disk drives;

a step of predicting the likelihood of occurrence of a failure for each of the disk drives based on information contained in said disk drive resource information table,

a step of, in response to a prediction that occurrence of a failure is likely to occur with respect to a data disk drive, and based on information contain in said spare disk drive resource information table, selecting two or more data disk drives as objects of divided data copy out of the plural data disk drives according to the predicted likelihood of occurrence of a failure;

a step of selecting two or more divided storage areas by selecting one divided storage area from each of the selected two or more data disk drives, wherein the selected two or more divided storage areas belong to different sets of data stripes in the parity group; and

a step of performing the divided data copy by controlling the subordinate side transfer control unit and the cache memory so as to copy data of the selected two or more divided storage areas to the one or more spare disk drives.

12. (original) A method according to claim 11, further comprising:

a step of selecting one data disk drive as an object of dynamic sparing out of the plural data disk drives according to the predicted likelihood of occurrence of a failure; and

a step of selecting remaining divided storage areas, from which data has not been copied to the spare disks, from the selected one data disk drive, and controlling the subordinate side transfer control units and the cache memory so as to copy data in the selected remaining divided storage areas to the spare disk drives.

13. (original) A method according to claim 12,

wherein the step of selecting two or more data disk drives is performed in the case in which the predicted likelihood of occurrence of a failure of a first data disk drive among the plural data disk drives has reached a first level, and then at least the first data disk drive and a separate second data disk drive are selected as objects of the divided data copy, and

the step of selecting one data disk drive is performed in the case in which the predicted likelihood of occurrence of a failure of the first data disk drive has reached a second level higher than the first level, and then the first data disk drive is selected as an object of the dynamic sparing.

14. (original) A method according to claim 11,

wherein the step of selecting two or more data disk drives is performed in the case in which the predicted likelihood of occurrence of a failure of the first disk drive among the plural disk drives has reached a predetermined level, and then the first data disk drive and a second data disk drive, which has the highest predicted likelihood of occurrence of a failure after the first data disk drive, are selected as objects of the divided data copy.

15. (original) A method according to claim 11,

wherein, in the controlling step, the subordinate side transfer control unit and the cache memory are controlled so as to read out data simultaneously from the selected two or more divided storage areas.

16. (original) A method according to claim 11, further comprising a step of, in the case in which a new request for writing data in the selected two

or more divided storage areas from the host device is received from the host side data transfer unit after the step of performing the divided data copy is started, controlling the subordinate side transfer control unit and the cache memory so as to write the new data received from the host device in the selected two or more divided storage areas and write the data in the spare disk drives as well to thereby update the data in the spare disks.

17. (original) A method according to claim 11,

wherein, in the step of selecting two or more data disk drives, first and second data disk drives are selected out of the plural data disk drives, and

in the step of selecting two or more divided storage areas, a first divided storage area belonging to a set of front side data stripes in the parity groups is selected from the first data disk drive, and a second divided storage area belonging to a set of rear side data stripes following the set of front side data stripes is selected from the second data disk drive.

18. (previously presented) A method according to claim 11,

wherein, in the step of selecting two or more divided storage areas, two or more divided storage areas having substantially the same size are selected.

19. (previously presented) A method according to claim 11,

wherein, in the step of selecting two or more divided storage areas, two or more divided storage areas having different sizes are selected according to

the likelihood of occurrence of a failure predicted for the two or more data disk drives.

20. (currently amended) A data sparing control device for use in a disk array device, which can be connected to a host device so that they are capable of communicating with each other, comprising:

a disk array control unit which performs control of the entire disk array device;

a host side data transfer control unit which controls data transfer to and from the host device;

a disk array including at least plural data disk drives which constitute one parity group and one or more spare disk drives, wherein the one parity group has a large number of data stripes which are formed over storage areas of the plural data disk drives and the large number of data stripes can be partitioned into two or more sets of the data stripes;

a cache memory which is used for temporary storage of data to be transferred between the host device and the disk array; and

a subordinate side transfer control unit which controls data transfer to and from the disk array,

wherein for controlling an operation for sparing data in the data disk drives using the spare disk drives, the data sparing control device comprises:

a prediction unit which predicts the likelihood of occurrence of a failure for each of the data disk drives;

wherein said prediction section includes a disk drive resource information table which includes for each data disk drive information indicating

a status of said data disk drive and information of a rate of occurrence of errors in said data disk drive and a spare disk drive resource information table which includes for each spare disk drive information indicating a status of said spare disk drive and information regarding storage areas of said spare disk drive used for recovery with respect to a corresponding data disk drive,

wherein said prediction section predicts the likelihood of occurrence of a failure based on information contained in said disk drive resource information table,

a divided area selection unit which, in response to a prediction that occurrence of a failure is likely to occur with respect to a data disk drive and based on information contain in said spare disk drive resource information table, selects two or more data disk drives as objects of divided data copy out of the plural data disk drives ~~according to the predicted likelihood of occurrence of a failure and~~ selects two or more divided storage areas by selecting one divided storage area from each of the selected two or more data disk drives, wherein the selected two or more divided storage areas belong to different sets of data stripes in the parity group; and
a divided data copy unit which controls the subordinate side transfer control unit and the cache memory so as to copy data of the selected two or more divided storage areas to the spare disk drives.

21. (new) A disk array device for storing data in response to communications from a host device, the disk array device comprising:

a disk array control unit which performs control of the entire disk array device;

a host side data transfer control unit which controls data transfer to and from the host device;

a disk array including at least a plurality of data disk drives which constitute one parity group and one or more spare disk drives, wherein the one parity group has a large number of data stripes which are formed over storage areas of the plural data disk drives and the large number of data stripes can be partitioned into two or more sets of the data stripes;

a cache memory which is used for temporary storage of data to be transferred between the host device and the disk array; and

a subordinate side transfer control unit which controls data transfer to and from the disk array,

wherein the disk array control unit comprises:

a prediction section which predicts the likelihood of occurrence of a failure for each data disk drive,

a disk drive resource information table which includes for each data disk drive information indicating a status of said data disk drive and information of a rate of occurrence of errors in said data disk drive,

a spare disk drive resource information table which includes for each spare disk drive information indicating a status of said spare disk drive and information regarding storage areas of said spare disk drive used for recovery with respect to a corresponding data disk drive,

wherein said prediction section predicts the likelihood of occurrence of a failure based on information contained in said disk drive resource information table, and

a divided data copy section which, in response to a prediction that occurrence of a failure is likely to occur with respect to a data disk drive, and based on information contain in said spare disk drive resource information table, selects two or more data disk drives out of the plural data disk drives as objects of divided data copy, selects two or more divided storage areas by selecting one divided storage area from each of the selected two or more data disk drives, the selected two or more divided storage areas belonging to different sets of the data stripes in the parity group, and controls the subordinate side transfer control unit and the cache memory so as to copy data in the selected two or more divided storage areas to the one or more spare disk drives,

wherein when the probability of failure occurring in a first data disk drive of the plurality of data disk drives reaches a first level, the divided data copy section selects two or more data disk drives including the first data disk drive out of the plurality of data disk drives as objects of divided data copy, selects two or more divided storage areas by selecting one divided storage area from each of the selected two or more data storage drives, and then performs a divided copying process,

wherein in the divided copying process, data stored in the divided storage areas of the selected two or more data disk drives are copied to one or more spare disks, but data stored in other storage areas of the selected two or more data disk drives are not copied to the spare disks,

wherein data in each of the other storage areas of the selected two or more data disk drives include data that are not parity data, and

wherein after performing the divided copying process, when the probability of the failure occurring in either one of the selected two or more data disk drives reaches a second level, which is higher than the first level, the divided data copy section copies the data stored in the other storage areas of the selected two or more data disk drives to the one or more spare disks.

22. (new) A disk array device according to claim 21,

wherein the disk array control unit further comprises a dynamic sparing section which selects one data disk drive as an object of dynamic sparing out of the plural data disk drives according to the predicted likelihood of occurrence of a failure, selects remaining divided storage areas, from which data has not been copied by the divided data copy section, from the selected one data disk drive, and controls the subordinate side transfer control units and the cache memory so as to copy data in the selected remaining divided storage areas to the spare disk drives.

23. (new) A disk array device according to claim 22,

wherein, in the case in which the predicted likelihood of occurrence of a failure of a first data disk drive in the plural data disk drives has reached a first level, the divided data copy section selects at least the first data disk drive and a separate second data disk drive as objects of the divided data copy, and

in the case in which the predicted likelihood of occurrence of a failure of the first data disk drive has reached a second level which is higher than the

first level, the dynamic sparing section selects the first data disk drive as an object of the dynamic sparing.

24. (new) A disk array device according to claim 21, wherein, in the case in which the predicted likelihood of occurrence of a failure of the first disk drive among the plural disk drives has reached a predetermined level, the divided data copy section selects the first data disk drive and a second data disk drive, which has the largest predicted likelihood of occurrence of a failure after the first data disk drive, as objects of the divided data copy.